Ukrainian Journal of
Veterinary and Agricultural Sciences
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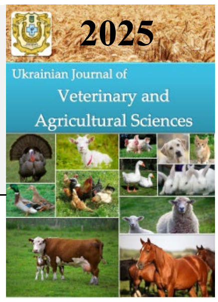

The Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv

Volume 8
Number 2

original article | UDC 636.52/.58.09:614.31:637.1/.05.07 | doi: 10.32718/ujvas8-2.14

Establishing the safety and quality of fish and fish products using unique methods

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Article info
Received 12.06.2025
Received in revised form 14.07.2025
Accepted 15.07.2025

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Contents

Abstract

Food business operators involved in the farming, storage, and sale of fish and the production of fish products must implement traceability systems and food safety assurance systems to enable risk-based control throughout the entire production cycle – from fish harvesting and processing to storage and retail. For the effective work of state veterinary inspectors during risk-based control at fish production and distribution facilities, it is recommended to implement the developed unique express and optimized methods for monitoring fish and fish products. These methods help establish quality and safety indicators and ensure compliance with shelf-life requirements through adherence to sanitary and hygienic standards at fish production and distribution sites. The recommended methods include: the peroxidase reaction, a photometric method for assessing fish freshness, bacterioscopic determination of the freshness of fish and fish products, measurement of the moisture-holding capacity of fish meat and fish products, and determination of histamine and sodium chloride content in fish products. These methods demonstrated a diagnostic accuracy of 99.3 %–99.9 % in testing. Research enabled the differentiation of chilled and frozen fish by assessing freshness using the peroxidase reaction: Fresh fish showed a blue-green color; Fish of doubtful freshness showed a light blue color; Spoiled fish showed an absence of blue-green coloration. Optimal optical density values of meat-water extracts with Nessler's reagent were identified: Up to 0.245 units (B) – fresh fish and fish products (light yellow color), From 0.246 to 0.545 B – fish and fish products of doubtful freshness (intense yellow color), From 0.546 to 0.845 B – spoiled fish and fish products (orange color). Using the unique express bacterioscopic method, the degree of freshness of fish and fish products was determined by counting the number of microorganisms in five visual fields on a single impression smear from the fish or fish product: Fresh – up to 10 microorganisms, Doubtful freshness – 11 to 30 microorganisms, Spoiled – more than 30 microorganisms. It was found that frozen fish had reduced moisture-holding capacity (MHC). For example: Frozen horse mackerel – 58.91 ± 0.06 %, Frozen catfish – 55.89 ± 0.04 %, Frozen mullet – 53.45 ± 0.08 %, Frozen mackerel – 51.32 ± 0.09 %. The highest MHC among fish products was recorded in: Medium-salted cold-smoked tuna – 64.6 ± 0.05 %, Medium-salted smoked silver carp – 60.32 ± 0.09%, Lightly salted salmon – 59.81 ± 0.07 %–all in accordance with regulatory standards. The histamine content in chilled, frozen fish and fish products did not exceed the regulatory limit of 100 mg/kg, except for hot-smoked horse mackerel, where histamine exceeded the limit by 2.31 %. The sodium chloride content in the tested fish product samples was within acceptable levels: Lightly salted: 6.0–9.0 %, Medium-salted: 9.0–13.0 %, Heavily salted: 13.0–19.0 %. The development and implementation of these unique, express, and optimized methods into the practice of veterinary professionals is highly relevant for advancing the methodology of assessing the safety and quality of fish and fish products.

Keywords: safety; quality; fish; fish products; unique methods; freshness.

Citation:
Bohatko, N. M., Bartkiv, L. G., Tyshkivska, N. V., Mazur, T. G., & Bohatko, A. F. (2025). Establishing the safety and quality of fish and fish products using unique methods. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 8(2), 81–87.

1. Introduction

Food market operators involved in the production, storage, and sale of fresh fish and fish products must implement a traceability system and the HACCP system for analyzing the emergence of hazardous risks (biological, chemical, physical), managing critical control points, and evaluating the results of obtained test data (Zhao et al., 2019; Ghalehjooghi et al., 2023). The effectiveness of HACCP and traceability systems, as an integral part of food safety management, provides assurance in the production of safe and high-quality food products for consumers, which is relevant and important for enhancing the image of processing facilities in Ukraine. Effective risk-based control at facilities for the production and circulation of fish and fish products requires the development of unique express and optimized methods for determining the safety and quality of fish products, as current monitoring is regulated by existing legal standards (Bohatko et al., 2024).

Researchers have paid considerable attention to the development of new express and optimized methods for controlling food safety and quality (Xuan et al., 2022; Li et al., 2024).

Modern consumers have become more demanding regarding the safety and quality of fish and fish products. Currently, risk-based control during the production, sale, and storage of fish and fish products is a pressing issue in veterinary medicine practice (Samarajeewa, 2023; Indio et al., 2024). HACCP teams at enterprises involved in the production and circulation of fish and fish products, guided by international legislation, must implement and rigorously adhere to prerequisite programs for the development, implementation, and application of continuously operating procedures (GVP, GLP, GHP, GMP), including maintaining appropriate temperature regimes for the storage of fish and fish products (Roobab et al., 2022).

The safety and quality control of fish and fish products is based on adherence to sanitary and hygienic requirements during their production, storage, and sale (Xia et al., 2023; Monteiro et al., 2024).

Currently used methods for assessing the safety and quality of fish and fish products at various stages of production, storage, and distribution have several significant limitations. These include: labor-intensive implementation; contradictory results that may complicate data interpretation; high costs due to expensive reagents and equipment; time-consuming testing procedures; and insufficient informativeness for comprehensive evaluation of microbiological, chemical, and organoleptic parameters (Bu et al., 2023; Lioupi et al., 2024). These factors complicate rapid decision-making, which is critical for perishable fish raw materials. Therefore, there is a need to modernize existing approaches, particularly through the implementation of innovative express methods that ensure high accuracy, speed, and reliability (Lee et al., 2024). Thus, developing and implementing unique, express, and optimized methods for the quality and safety control of fish and fish products is a crucial and timely direction in veterinary medicine practice. State veterinary inspectors play a key role in this process by monitoring and controlling all stages of the production and supply chain – from capture or farming to final sale (Kontominas et al., 2021; Kowalczyk, 2021).

This study aimed to evaluate the feasibility of applying developed unique express and optimized methods for determining quality and safety indicators of fish and fish products (peroxidase reaction, photometric method for assessing fish freshness, bacterioscopic determination of freshness, determination of moisture-holding capacity, and content of histamine and sodium chloride in fish products) to justify freshness assessment during storage periods and establish techno-chemical indicators under sanitary and hygienic conditions at fish production and distribution facilities.

2. Materials and methods

Samples of chilled fish at a temperature of 4 ± 2 °C (n = 16), frozen fish at –12 °C (n = 16), and fish products (n = 32) were examined at the State Enterprise “Kyiv Regional Scientific and Production Center for Standardization, Metrology and Certification” under state monitoring within its accredited scientific and production laboratory. The chilled and frozen fish and fish product samples were collected from fish production and distribution facilities. Experimental testing was conducted using patented, unique express and optimized methods to determine the freshness of fish in various thermal states, as well as the condition of fish products during their sale in the retail market.

The method for determining fish freshness via the peroxidase reaction was based on the qualitative identification of the peroxidase enzyme in fish gills. A 2.0–2.2 g gill sample was minced and mixed with 10.0–10.2 cm³ of distilled water (1:5 ratio) and left to stand for 12–14 minutes. The filtered extract (2.0–2.2 cm³) was then combined with 0.4–0.5 cm³ of a 0.3 % benzidine alcohol solution and 0.20–0.25 cm³ of a 1.5 % hydrogen peroxide solution. After shaking, the intensity of the coloration of the filtrate was assessed after 1–2 minutes. This method is protected by Ukrainian Patent No. 49405 (Bohatko et al., 2010).

The photometric method for determining the degree of freshness of fish and fish products involved measuring optical density based on the color intensity of a filtered meat-water extract reacted with Nessler's reagent using a photoelectric photometer. A 2.0–2.2 g sample of minced fish meat was mixed with 20.0–20.2 cm³ of distilled water (1:10 ratio) and left to stand for 12–15 minutes. A 4.0–4.2 cm³ portion of the filtered extract was then mixed with 1.0–1.2 cm³ of Nessler's reagent, shaken, and centrifuged at 1,000 rpm for 2–3 minutes. The optical density of the supernatant was immediately measured at 455–460 nm (blue filter) using a cuvette with a 1.0 cm light path. Distilled water was used as the control. This method is protected by Ukrainian Patent No. 49404 (Bohatko et al., 2010).

The bacterioscopic method for determining the degree of fish freshness was based on Gram staining of a smear-print from fish meat (Hooker modification), microscopic examination, and counting microorganisms in five fields of view to calculate the average number per field. Cell morphology (cocci, micrococci, rod-shaped bacteria), spore formation, and Gram reaction (Gram-positive or Gram-negative) were also recorded. This allowed for assessing microbial contamination and determining the degree of freshness. This method is protected by Ukrainian Patent No. 148888 (Lotskin et al., 2021).

The moisture-holding capacity (MHC) determination method was based on quantifying the retained moisture by pressing minced fish or fish product samples (100.0–150.0 g), thoroughly mixed to prevent juice loss. A 0.3–0.4 g portion was placed on a polyethylene disc on filter paper on a glass plate, covered with another glass plate, and pressed with a 1.0 kg weight for 9–10 minutes. After pressing, the sample was transferred to a pre-weighed drying box (büchs), dried at 105–106 °C for 4–5 minutes, and the MHC was calculated as a percentage using the respective formula. This method is protected by Ukrainian Patent No. 109387 (Bohatko et al., 2016).

The histamine content determination method in fish and fish products involved changing the quantity and concentration of reagents during the extraction of the test sample in a water bath at 60–61 °C. The sample was sequentially treated with a 5.0 % trichloroacetic acid solution, sodium hydroxide, sodium carbonate, saturated aqueous butanol-1, hydrochloric acid, and sodium carbonate. After freezing, ethyl acetate was added, shaken, and the absorbance of the pink-magenta solution was measured using a photoelectric colorimeter at 475 ± 10 nm (green filter) in a 5.0 mm light-path cuvette. Histamine content (mg/kg) was calculated using the corresponding formula. This method is protected by Ukrainian Patent No. 159111 (Bohatko et al., 2025).

The sodium chloride content determination method in fish products was based on the titration of dissolved chlorides with 0.05 mol/dm³ silver nitrate solution in the presence of 0.1–0.2 cm³ of 15.0% potassium chromate solution. Sodium chloride content (%) was calculated using the standard formula. This method is protected by Ukrainian Patent No. 86940 (Bohatko et al., 2014).

3. Results and discussion

Identification of Fish and Fish Product Freshness Using Unique Express Methods

The unique express method we developed for identifying the freshness of chilled and frozen fish was based on the qualitative determination of the peroxidase enzyme in fish gills through its interaction with 1.5 % hydrogen peroxide and 0.3 % alcoholic benzidine solution. The objective was to develop a reliable method for assessing fish freshness using gill samples and freshly prepared reagents. The appearance of a blue-green color indicated fresh fish due to the presence of peroxidase in the gills; a light blue color indicated questionable freshness; the absence of blue-green coloration was a sign of spoiled fish. The research results are presented in Table 1.

The unique photometric method we developed for assessing the degree of freshness of fish and fish products was based on quantitative determination of optical density (OD) of the meat-water extract with Nessler's reagent using a photoelectric photometer at a wavelength of 455–460 nm (blue filter). The color of the meat-water extract reacted with Nessler's reagent corresponded to the following OD ranges:

- Light yellow (fresh): up to 0.245 B;
- Intense yellow (questionable freshness): 0.246–0.545 B;
- Orange (spoiled): 0.546–0.845 B.

We also applied a unique bacterioscopic express method based on counting microorganisms in five fields of view in a Gram-stained smear-print from fish meat (Hooker modification). The slides were examined under immersion oil using a 90× objective and a 10× ocular. The results showed:

- Fresh fish/products: up to 10 microorganisms per field;
- Questionable freshness: 11–30 microorganisms;
- Spoiled fish/products: more than 30 microorganisms.

The fish and fish product analysis results are presented in Tables 1 and 2.

Table 1

Indicators of freshness of chilled and frozen fish at the point of sale using express methods (M ± m, n = 32)

Fish species	Peroxidase reaction (color intensity)	OD (meat extract + Nessler's reagent), B	Avg. number of microorganisms per field
Chilled carp	Blue-green	0.083 ± 0.005	6 ± 1
Chilled silver carp	Blue-green	0.123 ± 0.008	7 ± 1
Chilled pike	Light blue	0.316 ± 0.010	24 ± 2
Chilled crucian carp	No blue-green	0.587 ± 0.012	43 ± 3
Frozen catfish	Blue-green	0.162 ± 0.011	9 ± 1
Frozen horse mackerel	Light blue	0.273 ± 0.014	27 ± 2
Frozen mackerel	Blue-green	0.149 ± 0.007	8 ± 1
Frozen mullet	Blue-green	0.097 ± 0.004	5 ± 1

Note: Blue-green – fresh; Light blue – questionable freshness; No blue-green – spoiled. OD ranges: ≤ 0.245 B – fresh (light yellow), 0.246–0.545 B – questionable (intense yellow), 0.546–0.845 B – spoiled (orange)

Table 2

Optical density of meat extracts with Nessler's reagent and microorganism count in fish products at point of sale using express methods (M ± m, n = 34)

Fish product	OD (meat extract + Nessler's reagent), B	Avg. number of microorganisms per field
Semi-salted dried carp (n = 5)	0.657 ± 0.012	52 ± 3
Medium-salted smoked silver carp (n = 4)	0.048 ± 0.007	6 ± 1
Heavily salted herring (n = 6)	0.216 ± 0.011	9 ± 1
Medium-salted cold-smoked tuna (n = 3)	0.408 ± 0.008	29 ± 2
Lightly salted salmon (n = 3)	0.155 ± 0.010	8 ± 1
Lightly salted hot-smoked horse mackerel (n = 4)	0.176 ± 0.012	9 ± 1
Lightly salted mackerel (n = 5)	0.111 ± 0.006	7 ± 1
Lightly salted Atlantic trout (n = 4)	0.191 ± 0.004	5 ± 1

Note: OD ranges: ≤ 0.245 B – fresh (light yellow); 0.246–0.545 B – questionable freshness (intense yellow); 0.546–0.845 B – spoiled (orange)

According to Table 1, the following fish were identified as fresh based on the presence of blue-green coloration: chilled carp and silver carp, frozen mackerel and mullet. Their corresponding OD values were: Carp: 0.083 ± 0.005 B; Silver carp: 0.123 ± 0.008 B; Mackerel: 0.149 ± 0.007 B; Mullet: 0.097 ± 0.004 B.

Fish with questionable freshness included:

- Chilled pike: 0.316 ± 0.010 B;
- Frozen horse mackerel: 0.273 ± 0.014 B.

Spoiled fish was identified as:

- Chilled crucian carp: absence of blue-green color and OD 0.587 ± 0.012 B.

Bacterioscopic analysis confirmed the findings:

- Fresh: chilled carp, silver carp, frozen catfish, mackerel, mullet;
- Questionable: chilled pike, frozen horse mackerel;
- Spoiled: chilled crucian carp.

The reliability of the unique express methods was 99.9 % compared to standard national methods (Bohatko et al., 2024).

The results in Table 2 show that, according to the developed express method, the following fish products were identified as fresh (light yellow coloration of extract):

- Medium-salted smoked silver carp: 0.048 ± 0.007 B
- Lightly salted mackerel: 0.111 ± 0.006 B
- Lightly salted salmon: 0.155 ± 0.010 B
- Lightly salted hot-smoked horse mackerel: 0.176 ± 0.012 B
- Lightly salted Atlantic trout: 0.191 ± 0.004 B
- Heavily salted herring: 0.216 ± 0.011 B

Questionable freshness was found in:

- Medium-salted cold-smoked tuna: 0.408 ± 0.008 B (intense yellow)

Spoiled product:

- Semi-salted dried carp: 0.657 ± 0.012 B (orange coloration of extract)

Bacterioscopic evaluation confirmed:

- Fresh products: medium-salted smoked silver carp, heavily salted herring, lightly salted salmon, lightly salted hot-smoked horse mackerel, lightly salted mackerel, lightly salted Atlantic trout;
- Questionable: medium-salted cold-smoked tuna;
- Spoiled: semi-salted dried carp.

The reliability of the photometric and bacterioscopic express methods used to assess fish product freshness was 99.9 %, compared to the standard safety and quality assessment methods for fish products (Bohatko et al., 2024).

Determination of the Safety and Quality of Fish and Fish Products Using Unique Optimized Patented Methods

We conducted a series of tests to determine the moisture-holding capacity (MHC) of fish and fish products using a unique optimized method. This method was based on quantitative indicators obtained by pressing a sample of minced fish or fish product, followed by drying in an oven at 105–106 °C for 4–5 minutes. The moisture-holding capacity was then calculated as a percentage using a formula that considered the sample mass, moisture content in the pressed sample, and the difference in mass before and after pressing.

We also determined the histamine content in fish and fish products using a unique optimized method. The method involved quantitative measurement of histamine by altering the quantity and concentration of reagents during extraction and sequential processing with:

- 5.0 % trichloroacetic acid,
- sodium hydroxide,
- sodium carbonate,
- saturated aqueous butanol-1,
- hydrochloric acid, and again sodium carbonate.

After freezing, ethyl acetate was added, shaken, and the absorbance of the pink-magenta solution was measured at 475 ± 10 nm (green filter) using a photoelectric colorimeter. The histamine content was calculated in mg/kg using a specific formula.

In addition, we developed a unique optimized method for determining sodium chloride content in fish products. This involved titrating dissolved chlorides with 0.05 mol/dm³ silver nitrate solution in the presence of 0.1–0.2 cm³ of 15.0 % potassium chromate solution and calculating the percentage of sodium chloride using a standard formula.

The results of the fish and fish product evaluations using these unique optimized methods are presented in Table 3.

Table 3

Indicators of freshness of chilled and frozen fish and fish products using express optimized methods (M ± m, n = 66)

Type of fish / fish product	Moisture-holding capacity, %	Histamine content, mg/kg	Sodium chloride content, %
Chilled and frozen fish			
Chilled carp	72.62 ± 0.11	38.52 ± 0.03	–
Chilled silver carp	70.66 ± 0.12	31.43 ± 0.02	–
Chilled pike	68.23 ± 0.11	30.09 ± 0.02	–
Chilled crucian carp	73.82 ± 0.13	34.11 ± 0.03	–
Frozen catfish	55.89 ± 0.04	22.17 ± 0.03	–
Frozen horse mackerel	58.91 ± 0.06	23.01 ± 0.02	–
Frozen mackerel	51.32 ± 0.09	21.43 ± 0.02	–
Frozen mullet	53.45 ± 0.08	24.66 ± 0.03	–
Fish products			
Semi-salted dried carp	56.80 ± 0.07	73.12 ± 0.06	8.05 ± 0.02
Medium-salted smoked silver carp	60.32 ± 0.09	68.11 ± 0.06	11.83 ± 0.02
Heavily salted herring	57.74 ± 0.06	70.04 ± 0.06	14.08 ± 0.02
Medium-salted cold-smoked tuna	64.60 ± 0.05	69.02 ± 0.06	4.51 ± 0.02
Lightly salted salmon	59.81 ± 0.07	78.23 ± 0.06	7.28 ± 0.02
Lightly salted hot-smoked horse mackerel	55.31 ± 0.06	102.31 ± 1.06	6.33 ± 0.02
Lightly salted mackerel	47.22 ± 0.04	58.05 ± 0.06	6.54 ± 0.02
Lightly salted Atlantic trout	53.28 ± 0.06	68.66 ± 0.06	7.11 ± 0.02

Note: Maximum permitted histamine content: ≤ 100 mg/kg; Sodium chloride norms by salting type: Lightly salted: 6.0–9.0 %; Medium-salted: 9.0–13.0 %; Heavily salted: 13.0–19.0 %

Based on the results presented in Table 3, the highest moisture-holding capacity (MHC) was observed in chilled crucian carp – 73.82 ± 0.13 %, chilled carp – 72.62 ± 0.11 %, chilled silver carp – 70.66 ± 0.12 %, and chilled pike – 68.23 ± 0.11 %. These values are attributed to the cooling state and the chemical composition of the muscle tissue of these fish species. However, it was found that the MHC of frozen fish was reduced, namely: frozen horse mackerel – 58.91 ± 0.06 %, frozen catfish – 55.89 ± 0.04 %, frozen mullet – 53.45 ± 0.08 %, and frozen mackerel – 51.32 ± 0.09 %. Among fish products, the MHC was also somewhat lower, with the lowest values recorded in lightly salted mackerel – 47.22 ± 0.04 % and lightly salted Atlantic trout – 53.28 ± 0.06 %.

The highest MHC values among fish products were observed in medium-salted cold-smoked tuna – 64.6 ± 0.05 %, medium-salted smoked silver carp – 60.32 ± 0.09 %, and lightly salted salmon – 59.81 ± 0.07 %. All MHC values for both fish and fish products complied with regulatory standards. The accuracy of the results obtained by the unique optimized method for determining MHC was 99.4 % compared to results from conventional methods of fish and fish product safety and quality assessment.

The histamine content in chilled fish ranged from 30.09 ± 0.02 to 38.52 ± 0.03 mg/kg. In frozen fish, histamine levels were slightly lower, ranging from 21.43 ± 0.02 to 24.66 ± 0.03 mg/kg. These differences are associated with the thermal state and storage conditions of the fish. In hot-smoked horse mackerel, histamine content exceeded the permissible limit by 2.31 %. Compared to fish, fish products had significantly higher histamine content, although still within acceptable limits—ranging from 58.05 ± 0.06 mg/kg in lightly salted mackerel to 73.12 ± 0.06 mg/kg in semi-salted dried carp. The reliability of histamine measurements obtained using the optimized method was 99.3 %, in comparison with conventional methods for assessing fish product safety and quality.

The sodium chloride content in the tested fish products was within the regulated standards:

- for lightly salted products: 6.0–9.0 %,
- medium-salted: 9.0–13.0 %,
- heavily salted: 13.0–19.0 %.

The accuracy of sodium chloride determination by the unique optimized method was 99.8 % compared to conventional safety and quality testing procedures.

In addition, it should be emphasized that the patented unique express and optimized methods are simple to apply, cost-effective, reliable, and produce precise qualitative and quantitative indicators for determining the safety and quality of fish and fish products.

In the context of risk-based control of fish and fishery food products, it is essential to develop and implement effective testing methodologies to determine their suitability for consumption by the general population (Alak et al., 2023). The implementation of HACCP and traceability systems within the general framework of food safety management plays a critical role in ensuring the production of safe and high-quality fish products. These systems help minimize risks at every stage of production, storage, and distribution, while also allowing for prompt response to potential threats (Ogur, 2022). Their implementation is not only a technical or regulatory obligation, but also a strategic factor that significantly enhances consumer trust and strengthens Ukrainian processing enterprises' reputation in domestic and international markets. Improved competitiveness, growing demand, and a positive brand image are directly linked to compliance with modern safety and quality control standards (Bita & Sharifian, 2024).

Fish consumption is steadily increasing due to its health benefits, particularly the high content of unsaturated fatty acids, as well as its widespread use in modern food products, including raw fillets. Along with the development of the food industry and growing demand for long-shelf-life products, there is an urgent need to improve quality control methods. Specifically, there is a need to develop effective technologies for reliably monitoring the freshness and safety of fish products throughout their entire life cycle—from production and storage to transportation and consumption (Castrica et al., 2021).

Standard analytical methods for assessing fish freshness typically rely on determining chemical and physical parameters such as appearance, color, meat elasticity or texture, odor, and taste. Despite their widespread use, these methods have significant limitations (Franceschelli et al., 2021).

Advancements in effective freshness assessment are of key importance for increasing the accuracy of quality evaluation, ensuring consumer safety, and minimizing losses of valuable raw materials at various stages of the supply chain (Bernardo et al., 2020). Fish and fish products are highly perishable due to their high nutritional value and moisture content. The primary causes of spoilage include microbiological activity and chemical processes, especially lipid oxidation, which degrade product quality, alter organoleptic properties, and reduce market value. Therefore, the development of methods for detecting spoilage in fish products is necessary (Rathod et al., 2021).

Unlike traditional shelf-life extension techniques (e.g., smoking, salting, marinating, icing, chilling, freezing, drying, boiling, steaming), recent years have seen the development and implementation of a number of innovative alternative processing technologies that aim to preserve product quality with minimal impact on organoleptic and chemical indicators such as MHC, sodium chloride, and histamine (Speranza et al., 2021).

In this context, conventional storage methods (e.g., chilling and freezing) are being compared with advanced cold technologies, including supercooling. Modern approaches to fish product packaging are also being explored, such as edible films and coatings. A novel storage method—hyperbaric storage—is presented, involving controlled pressure increases to inhibit microbial growth and delay organoleptic spoilage under sub-zero, chilled, and room temperature conditions (Tavares et al., 2021).

A strategy has also been proposed for developing multifunctional natural active compounds formed during processing or packaging, which show great potential for odor control due to their safety and effective deodorizing properties (Wu et al., 2022). These advanced techniques aim to minimize spoilage and extend the shelf life of fresh fish products. However, their effectiveness largely depends on the type of product and storage conditions, particularly temperature (Siddiqui et al., 2024). Thus, based on scientific evidence, it is essential to develop unique express and optimized methods for assessing the safety and quality of fish and fish products.

4. Conclusions

The proposed unique express and optimized methods for determining peroxidase enzyme activity in fish gills, the optical density of meat-water extracts with Nessler's reagent, bacterioscopic assessment of the freshness of fish and fish products, moisture-holding capacity of fish meat and fish products, and the content of histamine and sodium chloride should be applied in the assessment of fish and fish product safety and quality. These methods are suitable for use in production laboratories at fish and fish product manufacturing facilities, wholesale storage centers, supermarkets and retail stores, regional laboratories of the State Service of Ukraine on Food Safety and Consumer Protection, and state veterinary and sanitary laboratories at agri-food markets.

The developed unique expression and optimized methods demonstrated reliability ranging from 99.3 % to 99.9 % in identifying quality and safety indicators of fish and fish products, in comparison with conventional methods established by national standards.

Prospects for further research lie in the development of unique, optimized methods for the bacteriological determination of fish and fish products.

Conflict of interest

The authors declare that there is no conflict of interest.

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